Assessment of Effective Control Methods for Parthenium Weed in Maize Fields

***Wambura, H. D.*[1*], *Kudra A. B.*[2] *Andrew, S. M*[2]. *and Witt, A.*[3]**

[1] Mwalimu Julius K. Nyerere University of Agriculture and Technology, P.O Box 976, Musoma-Mara
[2]Sokoine University of Agriculture, P.O. Box 3000, Morogoro-Tanzania
[3]CABI International, P.O Box 633-00621, Nairobi-Kenya
*Corresponding author: hamisdaniel@gmail.com

Abstract

In the near future, labour to assist in weed management in the villages will become scarce and expensive, because of population drift from villages to cities. It is necessary to develop cheaper methods of weed management that will reduce weed impact on maize yield. A field experiment was conducted at the Tropical Pesticides Research Institute (TPRI), Arusha-Tanzania during the long rain season of 2017, to identify control methods for parthenium weed (Parthenium hysterophorus L.). The experiment was laid out in a randomized complete block design (RCBD) with four replications. Treatments were hand hoeing (twice), mulches (dry grass and cowpeas), application of 2, 4-D (twice), weed free plots and un-weeded plots. Data collected include plant height at flowering (m), leaf length and width (m), number of leaves at flowering, number of days to (tasseling, silking and milking), tassel length (m), number of days to maize maturity, plant height at maturity (m), number of plants harvested, ear length and diameter (m), number of kernel rows/ear, number of kernels/row and grain yield (t/ha)at 12% moisture content, parthenium weed plant height (m), canopy width (m), and number of parthenium plants before weeding, height (m) and number of parthenium plants at maize maturity. Statistical analysis was performed using Genstat software (16th edition) and means were separated by Tukey's mean separation test at $p \le 0.05$. The results show that, mulches significantly reduced parthenium height and population in the maize crop at maturity ($p<0.05$). Plant height at flowering, leaf length and width, number of days to tasseling, tassel length, number of days to silking, milking, maturity, plant height at maturity and number of plants harvested were not significantly affected by any of the weed management methods. Thus mulching and 2, 4-D were found to be the best methods for controlling parthenium weed growth and population.

Key words*:Parthenium weed, Control methods, Maize, Weeds*

Introduction

Maize (Zea mays) is the world's widely cultivated highland cereal and primary staple food crop in many developing countries. Pradeep *et al*. (2017) ranked maize as the third in cereals world production after rice and wheat, but in productivity, it surpasses all cereals. In Tanzania maize is one of the dependable food and cash cereal crops but its production has been hindered by both biotic and abiotic factors. Among the biotic constraints, weeds are considered as an important category. Invasive weeds are considered to be among the biotic factors that hinder maize production. Parthenium weed is one of the threatening invasive weeds due to its allelopathic properties, as it produces parthenin compound that hinders germination of crop seeds and hence reducing crop establishment and yields (Tomado *et al*., 2002a; Singh *et al*., 2004).

Various methods have been tested to reduce the impact of parthenium on crop production in countries like Australia, Sri-Lanka, India, Pakistan and Ethiopia. For example, herbicides have proved effective for the control of parthenium weed. Singh *et* *al*. (2004) found that atrazine and 2, 4-D caused 45% mortality to parthenium weed in India when applied to young plants. Shabbir, (2014) discovered that, Glyphosate and Isoproturon are effective selective herbicides in controlling parthenium weed although Glyphosate was comparatively more effective as compared to Isoproturon. Methods such as manual weeding and use of atrazine, hexazinone and biological control, using a moth (Epiblema strenuana) have been suggested by Masum *et al*. (2009) and Abebe and Chemeda, (2016) to manage parthenium weed in Bangladesh.

Manual uprooting of parthenium weed before flowering and seed setting is the most effective method. This is due the fact that, uprooting the weed after seed setting will lead to weed seed dropping and hence increase the area of infestation (Manpreet *et al*., 2014). The author reported that, although there are some landholders that have achieved success in ploughing parthenium weed in the rosette stage before it seeds, but this must be followed up by sowing a crop or direct seeding the perennial pasture. Talemos *et al*. (2013) argued that, parthenium weed management practices like manual uprooting should be handled with care, which is, a person should make sure that protective gear such as gloves and masks are in place to prevent health hazards of the weed.

Serious inspection of parthenium weed seeds at border entry points and Airports could be a proper method of preventing and managing the weed. In South Africa, the weed is regulated as well under the existing legislation (Conservation of Agriculture Resources Act 2002-Category 1 according to which invader plants must be removed and destroyed immediately. No trade in these plants and is also reported as a noxious weed by the government of Kenta and Puerto Rico (European Plant Protection Organisation, 2014).

Despite the presence of some effective control measures, these technologies have not been used widely in Tanzania. Furthermore, from a wide range of available technologies, selecting appropriate combination suitable for the area based on existing cropping systems is yet to be established. Therefore, the present research work was carried out to evaluate different weed management practices with intension of obtaining the most effective and easily adoptable weeding technique in controlling parthenium weed in maize fields.

Materials and Methods

Description of the study area

A field experiment was conducted at the Tropical Pesticides Research Institute (TPRI) in Arusha, Tanzania, during the long rain season from February to July 2017. TPRI is located at 3º1953.265’’S latitude and 36º37.38.667’E longitude and at an elevation of 1451m above sea level. Selection of the experimental site was done following the presence of parthenium weed based on the survey report carried in March 2011 (Clark and Lotter, 2011).

Methods

Parthenium weed seeds were broadcasted in equal amounts in each plot of maize. The experimental site was ploughed and leveled before the field layout was made. The experiment consisted of six treatments namely weed free, hand hoeing, dry grass mulching, 2, 4-D application; cover crop mulching (cowpeas) and no weeding. Hand weeding and 2, 4-D applications were twice (4th and 8th week after planting). The herbicide, 2, 4-D was applied at the rate of 960g a.i/ha in a plot area of 9m^2. The treatments were arranged in randomized complete block design (RCBD) with four replications. The distance between adjacent replications and plots were 1m each.

A maize variety SC 403 was used as a testing variety, which was sown by the dibbling method. Thus, space between one plant and another was 0.03m while rows were spaced at 0.75m. There were 4 rows per plot and 10 plants per row. Urea fertilizer was applied 16 days after sowing by banding method at the rate of 102kgN/ha. Other weeds were removed from the experimental plots by hand hoeing or hand pulling as soon as they emerged.

Data collection and analysis

Data were collected based on maize descriptor prepared by Badu-Apraku *et al*. (2012). The collection of maize data was done from ten (10) plants in the two middle rows with 3.6 m2 as sampling area. Statistical analysis was performed using Genstat software (16th edition) and means were separated using the Tukey mean separation test ($p<0.05$). Analysis of variance was done based on the statistical model for randomized complete block design: $Y_{ij} = \mu + \alpha_i + b_j + \varepsilon_{ij}$ whereby Y_{ij} indicates random variable representing the response for treatment (i) observed in block j, μ is the constant (which may be thought of as the overall mean, α_i stand for the (additive) effect of the ith treatment, b_j is the (additive) effect of the jth block, ε_{ij} is the random error for the ith treatment in the jth block.

Results and Discussions

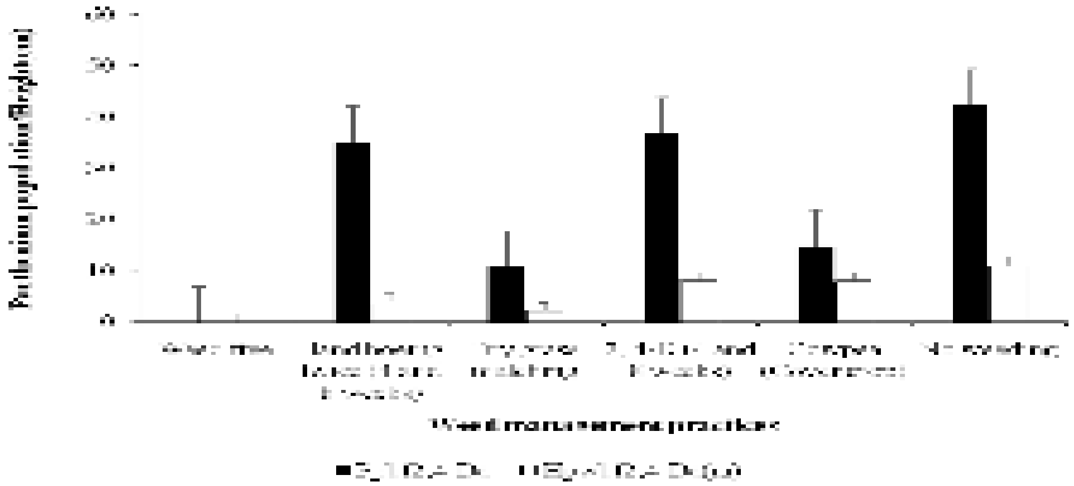
Results

Effect of control method on parthenium weed population and height before first weeding and 2, 4-D application

Population and height of parthenium weed was observed to be significantly different ($p<0.05$) among the applied treatments. Plots treated with dry grass mulches had lower parthenium weed population and height than cover crop treated plots while high parthenium weed population and height were observed from un-weeded plots (Fig. 1). Hand weeding was observed to reduce height of the weed compared to when a plot was left un-weeded.

Effect of control method on population and height of parthenium weed after maize maturity

Statistical differences were observed to be significant ($p<0.05$) among treatments in parthenium weed population and height at maize maturity (Fig. 2). A plot treated with cowpea as cover crop had lower parthenium weed population followed by cover crop plots and 2, 4-D plots while higher parthenium weed population was observed in the un-weeded plots (Fig. 2). Lowest parthenium weed height was recorded in dry grass mulched plots while the highest height was observed in the un-weeded plots.



(Ppbf2, 4-Da – Parthenium weed population before first weeding and 2, 4-D application, Hpwbf2, 4-Da – Height of Parthenium weed before first weeding or 2, 4-D application)

Figure 1: Effect of control method on parthenium weed population and height before first weeding or 2, 4-D application

(Pwpamm – Parthenium weed population after maize maturity, Hpwamm – Height of parthenium weed (cm) after maize maturity

Figure2: Effect of control method on parthenium weeds population and height (cm) after maize maturity)

Effect of control method on plant height, number of leaves, leaf length and leaf width at flowering

Plant height was not significantly affected by the applied management practices of the parthenium weed in the maize field (Table 1). The tallest maize plants were observed in plots with 2, 4-D while the shortest were observed in control plots (no weeding and weed free). Not only on plant height but also leaf length, leaf width and number of leaves were not statistically affected by the weeding methods. However number of leaves was slightly higher with 2, 4-D (Table 1).

Table 1: Effect of control method on plant height, number of leaves, leaf length and leaf width at flowering

Treatments	Plant height at flowering (m)	Number of leaves at flowering	Leaf length/plant (cm)	Leaf width (cm)
Weed free	1.43[a]	11[a]	13.37[a]	7.37[a]
Hand hoeing twice (4 and 8 weeks)	1.43[a]	11[a]	13.27[a]	7.59[a]
Dry grass mulching	1.49[a]	11[a]	13.46[a]	7.94[a]
2, 4- D (4 and 8 weeks)	1.57[a]	12[a]	13.46[a]	7.61[a]
Cowpea (Cover crop)	1.50[a]	12[a]	13.46[a]	7.89[a]
No weeding	1.45[a]	12[a]	12.16[a]	7.67[a]
Grand mean	1.48	11	13.38	8
SE±	0.068	0.3	0.8	0.4
P-value	0.296	0.131	0.26	0.702
CV (%)	7.9	3.9	2.7	6.9

*Means that share a letter within a column are not significantly different by Tukey mean separation test ($P \leq 0.05$)

Influence of control method on number of days to 50% tasseling, tassel length, number of days to 50% silking and number of days to milking

The parthenium weed management practices did not significantly affect number of days to 50% tasseling, tassel length, number of days to silking and number of days to milking in maize (Table 2). Maximum number of days to tasseling, silking and milking was observed from weed free plots. The data also showed that the maize variety used (SC 403) took almost 18 days to milking stage after silking.

Effect of control method on number of days to maturity and plant height

Results in Table 3 indicate that number of days to maize maturity was not significantly different among parthenium weed management practices. However, maximum number of days to maize maturity was recorded with dry grass mulch application while maize plants took relatively short days to mature when 2, 4-D was applied. The shortest maize plants at maturity were recorded in un-weeded plot while the tallest maize plants were noted in plots applied with dry grass mulch.

Table 2: Influence of control method in number of days to 50% tasseling, tassel length, number of days to silking and number of days to milking

Treatments	Days to 50% tasseling	Tassel length (cm)	Days to silking	Days to milking
Weed free	73.25^{a}	27.93^{a}	79.25^{a}	94.75^{a}
Hand hoeing twice (4 and 8 weeks)	71.25^{a}	27.88^{a}	78.00^{a}	93.25^{a}
Dry grass mulching	72.50^{a}	27.98^{a}	77.75^{a}	93.75^{a}
2, 4- D (4 and 8 weeks)	71.25^{a}	27.50^{a}	77.25^{a}	93.00^{a}
Cowpea (Cover crop)	71.25^{a}	27.60^{a}	77.75^{a}	94.00^{a}
No weeding	71.25^{a}	26.85^{a}	78.50^{a}	93.75^{a}
Grand mean	71.66	27.62	78.08	93.75
SE±	0.971	1.245	0.940	0.922
P-value	0.257	0.943	0.395	0.516
CV (%)	0.8	1.5	1.5	0.7

*Means that do not share a letter within a column are significantly different by Tukey mean separation test ($P \leq 0.05$)

Table 3: Effect of control method on number of days to maturity and plant height at maturity

Treatments	Days to 50% maturity	Plant height at maturity (m)
Weed free	142.8^{a}	1.89^{a}
Hand hoeing twice (4 and 8 weeks)	143.2^{a}	1.94^{a}
Dry grass mulching	152.5^{a}	1.99^{a}
2, 4- D (4 and 8 weeks)	142^{a}	1.98^{a}
Cowpea (Cover crop)	143^{a}	1.93^{a}
No weeding	142.5^{a}	1.85^{a}
Grand mean	142.67	1.93
SE±	0.553	0.067
P-value	0.333	0.314
CV (%)	0.3	4.1

*Means that do not share a letter within a column are significantly different by Tukey mean separation test ($P \leq 0.05$)

Effect of control method on number of plants harvested, number of ears and ear length.

Despite of many maize plants being harvested when hand hoeing was practiced and few plants harvested in weed free treated plots, these practices did not affect significantly number of maize plants and ears harvested. Additionally, Ear length and ear diameter were also not significantly affected by the weeding methods (Table 4).

Table 4: Effect of control method on number of plants harvested, number of ears and ear length

Treatments	Number of plants harvested	Number of ears harvested	Ear length (cm)	Ear diameter(cm)
Weed free	25^{a}	25^{a}	13.37^{a}	4.89^{a}
Hand hoeing twice (4 and 8 weeks)	27^{a}	27^{a}	13.27^{a}	4.86^{a}
Dry grass mulching	26^{a}	26^{a}	13.86^{a}	4.79^{a}
2, 4- D (4 and 8 weeks)	26^{a}	27^{a}	14.17^{a}	0.048^{a}

Cowpea (Cover crop)	26^{a}	26^{a}	13.46^{a}	4.96^{a}
No weeding	26^{a}	26^{a}	12.16^{a}	4.61^{a}
Grand mean	25.88	26	13.38	4.82
SE±	3.057	3.038	0.806	0.14
P-value	0.999	0.997	0.49	0.262
CV (%)	8.3	8.7	2.7	3.6

*Means that do not share a letter within a column are significantly different by Tukey mean separation test (P≤0.05)

Effect of control method on number of kernel rows, number of kernels/ha and grain yield (t/ha)

Maize variety (SC 403), produced ears with almost the same number of kernel rows since significant differences was not found as shown in Table 5. Same number of plants and ear size was also harvested to every plot (Table 4.5). In addition pollination succeeded in the same rate to every plot.

Results in Table 5 show that there were similar number of kernels per cob that resulted into similar maize yield (t/ha).

Table 5: Effect of control method on number of kernels row, number of kernels/ha and total kernels weight (t/ha)

Treatments	Kernel rows/ha	Kernels/ha	Grain yield (t/ha)
Weed free	37500^{a}	73264^{a}	5.27^{a}
Hand hoeing twice (4 and 8 weeks)	37639^{a}	75278^{a}	6.12^{a}
Dry grass mulching	36528^{a}	81042^{a}	6.27^{a}
2, 4- D (4 and 8 weeks)	37917^{a}	81875^{a}	5.69^{a}
Cowpea (Cover crop)	37500^{a}	78264^{a}	6.86^{a}
No weeding	35208^{a}	68681^{a}	5.41^{a}
Grand mean	37049	76400	5.94
SE±	1029.8	5777.8	1.293
P-value	0.145	0.246	0.827
CV (%)	6.6	3.6	14.8

*Means that do not share a letter within a column are significantly different by Tukey mean separation test (P≤0.05).

Discussions

These results indicate that dry grass mulching and cover crop were the best management practices in reducing parthenium growth over the control (no weeding) plot. Thus, Dry grass and cowpea (cover crop) covered almost the whole plot, therefore they hindered parthenium weed to emerge by inhibiting light reaching the weed. Thus insufficient light hindered parthenium weed establishment and growth. The parthenium weed seeds were able to germinate and emerge easily only in spots which were not well covered by mulch. These results are similar to those reported by Nishanthan *et al*. (2013) in which high parthenium weed density was observed from un-weeded plots and mulching suppressed its growth. Parthenium weed germinated and emerged where there was insufficient cover by the mulch (Nishanthan *et al*., 2013). Parthenium weed in the un-weeded plots had higher population and taller plants since they were not disturbed with any weed management practices. Dry grass and cover crop mulches delayed parthenium weed emergence and even where they emerged maize crop was already full-established and provided shading effect to the weed which resulted into poor growth. Thus, grass mulch hinders parthenium weed growth and favors growth of maize plants by conserving soil moisture as well as suppressing growth of other weeds (Florence *et al*., 2015).

Additionally, application of 2, 4-D was the best management practices for reducing parthenium plant height over the control (no weeding). Thus, application of 2, 4-D two weeks after planting killed almost all parthenium weeds. New parthenium weeds that germinated were also killed when 2, 4-D was applied for the second time (8th week after planting).

Cover crop mulch (cowpea plants) could be used by farmers to manage parthenium weed since it reduced parthenium weed growth and population by inhibiting its emergence through shading effect. Apart from reducing parthenium weed population, also cowpeas plants fixed nitrogen in the soil and hence became available to maize plants (Papa *et al*. 2015). Similar results were reported by Haroon *et al*. (2012) who reported that 71-80% of parthenium weed was controlled four weeks after 2, 4-D application while un-treated plot could not provide a mean mortality of over 80% to parthenium weed (Goodall *et al*.,2010).

Maize emerged earlier than parthenium weed and thus out-competed the weed resulting in greater plant height, leaf length and width. Wajeeh *et al*. (2016) reported similar results. They noted weeding methods were not affecting significantly on maize plant height. Although many leaves were counted when 2, 4-D, cowpeas and dry grass mulches were observed. These could be due to the effectiveness of the applied weed management methods that provided a chance for maize to explore all available nutrients for its growth. This is similar to Larbi *et al*. (2013) who observed the greatest number of leaves with 2, 4-D application.

Weed management methods such as dry grass mulch, cover crop and 2, 4-D affected parthenium weed growth. However, it did not reach a level to compete with maize plants. Maize, being the first to emerge and establish, it cause the weed not to affect maize growth parameters such as number of days to silking, days to tasseling and milking. This concurs with the results of Nleya *et al*. (2016) who reported that kernel milk stage occurred approximately 18 to 22 days after silking.

In order for a weed to suppress growth of a plant it must out-compete the grown plant. Late parthenium weed germination even in un-weeded plot favored maize plant growth and hence caused applied weed management methods not to have statistical differences in plant height and number of day to maize maturity. Additionally, the results provide the information that maize variety used (SC 403) had almost the same ear length and diameter. This could be due to maize crop being the first to emerge before the weed and hence managed to use effectively the available resources such as moisture, oxygen and nutrients. These results were similar to those of Tesfay *et al*. (2014) who observed longest ears (16.3, 19.2 cm) with hand weeding and hoeing respectively, but not significant.

Factors such as plant population, ear size and success at pollination were not affected by the parthenium weed, that's why there was no significant difference in number of kernel rows and number of kernels per hectare. The number of kernel per hectare depends upon plant population, ear size and success at pollination (Jeff, 2010). These results may imply that, rate and duration of grain filling was unaffected by the parthenium weed. Parthenium weed did not out-compete the maize crop, thus not affecting grain yield. Maize emerged and well established before the weed from un-weeded plot hence dominated the cropped area and got all necessary requirements for its growth. Thus, they grew taller than parthenium weeds; hence maize had advantage of light over the weed. The weed should out-compete a respective crop in nutrients, moisture and air so that to alter its growth (Montserrat *et al*., (2004). Therefore, this made grain yield in the un-weeded plots to be similar to weeded ones. Grain yield is directly related to number of kernels per cob (Wajeeh *et al*., 2016). The number of rows per cob is a genetically controlled factor but environmental and nutritional level may alter the number of rows per cob (Muhammad *et al*., 2008). Thus, the grain yield being not affected despite of applying weed management practices could be attributed by environment and/or nutritional level of the soil which were not in favor of facilitating kernel rows emergence in a maize cob.

Conclusions and Recommendations

Conclusions

The study demonstrated that parthenium weed population can highly be reduced by applying 2, 4-D, dry grass mulches and cover crop mulching as weed management practices. Additionally, cowpea mulch and 2, 4-D treatments, dry grass mulch was noted to reduce height of parthenium weed. However, application of 2, 4-D reduced parthenium weeds population as compared to hand hoeing. Notwithstanding, after maize maturity, height of parthenium weed was observed to be highly reduced in plots treated with dry grass and cowpea mulches.

Recommendations

2, 4-D reduced parthenium weed more than mulching but should not be the first option due to its health hazards. Therefore researchers and farmers should go for other weed control options. This research work recommends the use of cover crop mulching (cowpea plants) to be the best option for farmers to manage parthenium weed since it was among the best practices in reducing parthenium weed growth and population by inhibiting its germination through shading effect provided by the large canopy of cowpea plants.

Resultsof this study were obtained from a single season experiment. Therefore, more research should be carried out in order to confirm current results and work on economically viable and environmental friendly control method of parthenium weed in maize field.

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References

Abebe, B and Chemeda, A. (2016). A review on the Distribution, Biology and Management Practices of Parthenium Weed, Parthenium hysterophorus L.) In Ethiopia. Journal of Biology, Agriculture and Healthcare 6(5): 136-145.

Badu-Apraku, B., Fakorede, M.A.B., Menkir, A.and Sanogo, D. (2012). Conduct and Management of Maize Field Trials. International Institute for Tropical Agriculture., Nigeria. 59pp.

Clark, K. and Lotter, W. (2011). What is Parthenium Weed up to in Tanzania? In: Proceeding of International Parthenium conference. (Edited by Asad, S. and Steve, W.A.), 3 January 2011, The University of Queensland, Australia. 1-11pp.

Florence, M., Hatirarami, N., Tonny, T., Christopher, C., Muneta, G.M.and Paul, M. (2015). Mulching and Fertilization Effects on Weed Dynamics under Conservation Agriculture Based Maize Cropping in Zimbabwe. Environments 2(1):399-414.

Goodall, J., Braack, M., de Klerk, J and Keen, C. (2010). Study on the Early Effects of Several Weed-Control Methods on Parthenium hysterophorus L. African Journal of Range and Forage Science 27(1): 95-99.

Haroon, K., Khan, B.M., Gul, H., Muhammad, A.K. (2012) Chemical Control of Parthenium hysterophorus L. at Different Growth Stages. Pakistan Journal of Botany 44(5): 1721-1726.

Jeff, C. (2010). Grain Filling Rates in Corn. In: National Crop Insurance Services Regional/State Meeting Flandreau. (Edited by Waseca and Lamberton, M.N), 5 January 2010, United States of America. 41pp.

Larbi, E., Ofosu-Anim, J., Norman, J.C., Anim-Okyere, S. and Danso, F. (2013). Growth and Yield of Maize (Zea mays L.) in Response to Herbicide Application in the Coastal Savannah Eco zone of Ghana. Net Journal of Agriculture Science 1(3): 81-86.

Manpreet, K., Neeraj, K.A., Vikas, K. and Romika, D. (2014). Effects and Management of Parthenium hysterophorus: A Weed of Global Significance. International Scholarly Research Notices, 1-12pp.

Masum, S.M., Mirza, H. and Ali, H. (2009).Threats of Parthenium hysterophorus on Agro-Ecosystems and its Management. Journal of Environmental Biology 27(3): 449-453.

Montserrat, V., Mark, W. and Mark, L. (2004). Competition Experiments on Alien Weeds with Crops: Lessons for Measuring Plant Invasion Impact. Biological Invasions 6: 59-69.

Muhammad, T., Asif, T., Asghar A., Muhammad, A. and Allah, W. (2008). Comparative Yield Performance of Different Maize Varieties (Zea mays L.) Hybrids under Local Conditions of Faisalabad- Pakistan. Pakistan Journal of Life Social Science 6(2): 118-120.

Nishanthan, K., Sivachandiran, S. and Marembe, B. (2013). Control of Parthenium hysterophorus L. and its Impact on Yield Performance of Tomato (Solanum lycopersicum L.) in the Northern Province of Sri Lanka. Tropical Agricultural Research 25(1): 56-68.

Nleya, T., Chungu, C. and Kleinjan, J. (2016). Corn Growth and Development. In:I Grow Corn: Best Management Practices (Edited by Clay, D.E., Carlson, S.A, and Byamukama, E.), South Dakota State University. 5-10pp.

Papa, S.S., Shunsei, F. and Takeo, Y. (2015). Nodulation, Nitrogen Fixation and Growth of Rhizobia-Inoculated Cowpea (Vigna unguiculata L.) in Relation with External Nitrogen and Light Intensity. International Journal of Plant Biology and Research 3(1): 1025.

Pradeep, R., Sreenivas, G. and Leela, R.P. (2017). Impact of Sustainable Weed Management Practices on Growth, Phenology and Yield of Rabi Grain Maize (Zea mays L.). International Journal of Current Microbiology and Applied Sciences 6(7):701-710.

Shabbir, A. (2014). Chemical Control of Parthenium hysterophorus L. Pakistan Journal of Weed Science 20(1): 1-10.

Singh, S., Yadav, A., Balyan, R.S., Malik, R.K. and Singh, M. (2004).Control of Ragweed Parthenium (Parthenium hysterophorus) and Associated Weeds. Weed Technology 18:658-664.

Talemos, S., Abreham, A., Fisseha, M. and Alemayehu, B. (2013). Distribution Status and Impact of Parthenium Weed (Parthenium hysterophorus L. at Gedeo Zone (Southern Ethiopia). African Journal of Agricultural Resources 8(4): 386-397.

Tesfay, A., Amin, M., Mulugeta, N. and Frehiwot, S. (2014). Effect of Weed Control Methods on Weed Density and Maize (Zea mays L.) Yield in West Shewa Orimia, Ethiopia. African Journal of Plant Science 9(1): 8-12.

Tomado, T., Schultz, W. and Milberg, P. (2002a). Germination, Ecology of the Weed Parthenium hysterophorus in Eastern Ethiopia. Annals of Applied Biology 140: 263-270.

Wajeeh, U.D., Khalid, N., Shahid, I., Anwar, A., Shah, MK., Naushad, A. and Izhar, H. (2016). Effect of Different Weeding Intervals and Methods on the Yield and Yield Components of Maize. ARPN Journal of Agricultural and Biological Science 11(3): 1990-6145.